Hunting for narrow resonances in the dijet mass spectrum at CMS

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on behalf of the CMS Collaboration

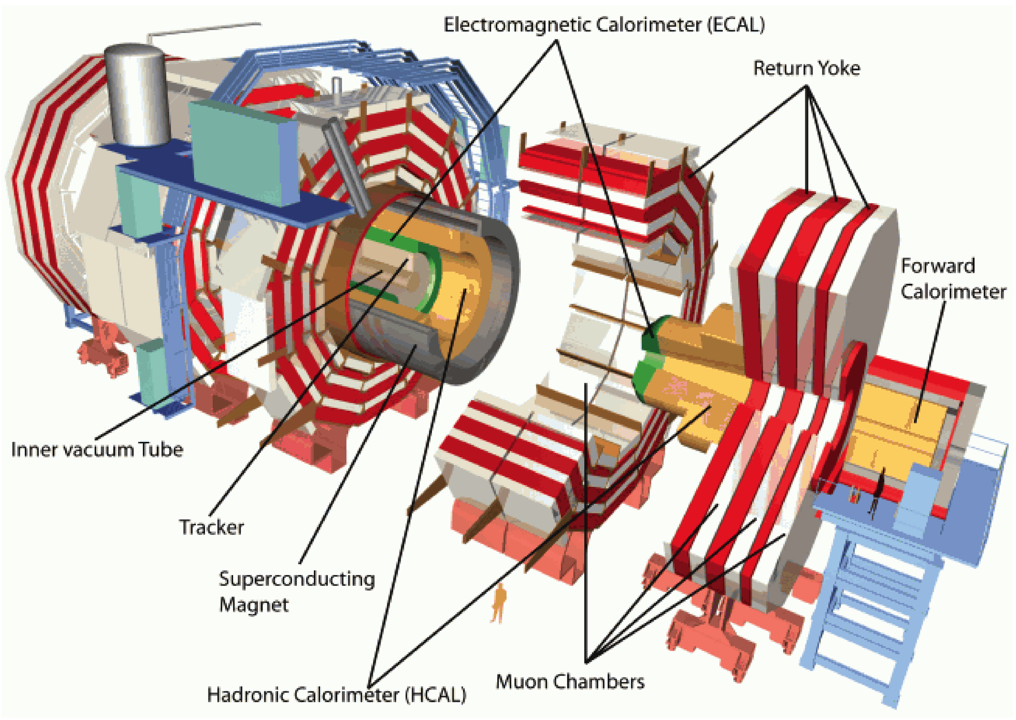
The LHC

The Large Hadron Collider (LHC) is the largest and most powerful collider worldwide : two proton beams intersect in four collision points, one of which is the location of the CMS Experiment.

The main goal of the LHC experiments, after the discovery of the Higgs Boson, is to shed light on key questions like:

- The nature of Dark Matter.
- The origin of the dramatic matter - antimatter asymmetry in the Universe.
- The hierarchy problem.
- The unification of couplings and forces
- The origin of flavor.

The CMS Experiment



Pixels
$\sigma/p_T \sim 1.5 \cdot 10^{-4} p_T(\mathrm{GeV}) \oplus 0.005$

Electromagnetic Calorimeter
$\sigma_E/E \approx 2.9\%/\sqrt{E(\mathrm{GeV})} \oplus 0.5\% \oplus 0.13\mathrm{GeV}/E$

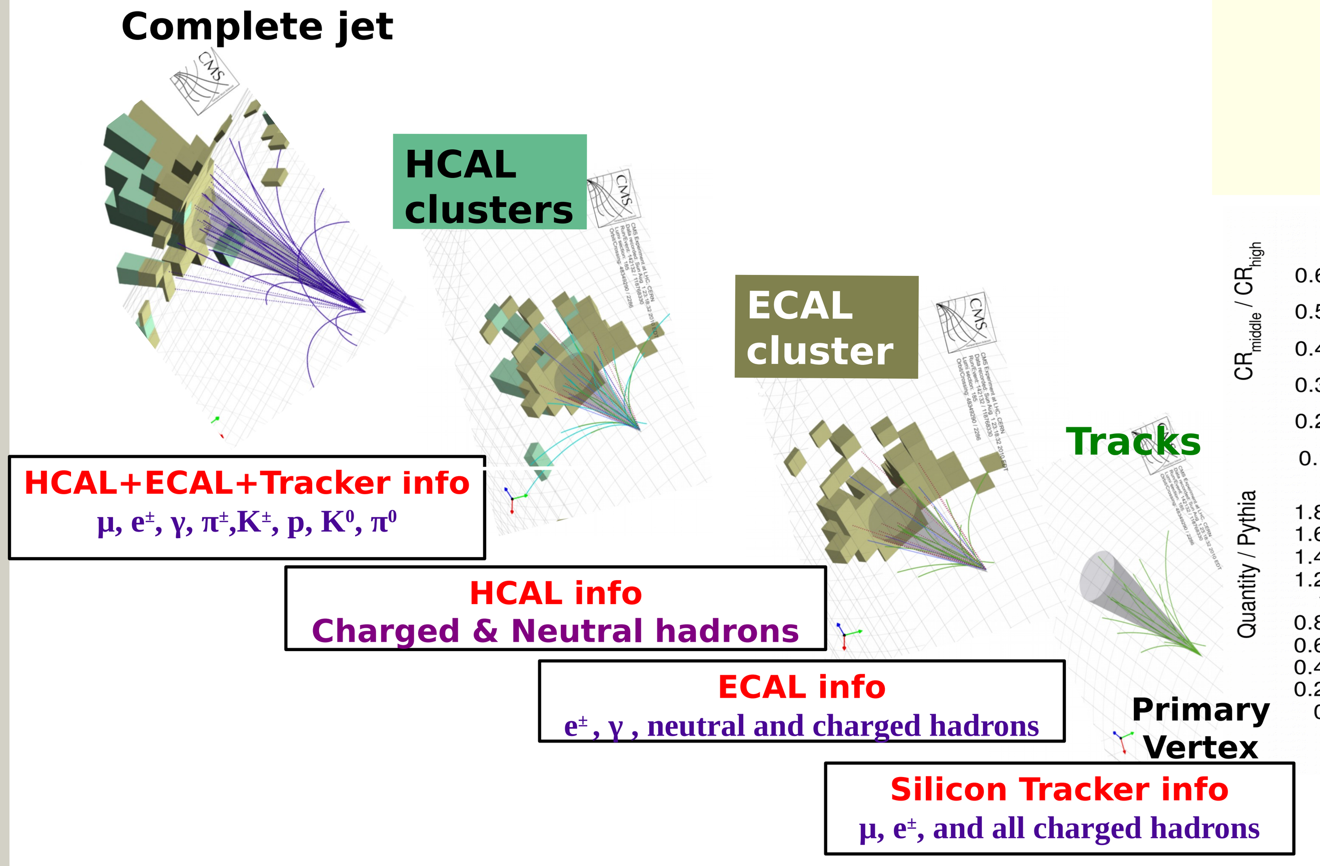
Hadronic Calorimeter
$\sigma_E/E \approx 120\%/\sqrt{E(\mathrm{GeV})} \oplus 6.9\%$

Muon Spectrometer
$\sigma_{pT}/p_T \approx 1\%$ for low pT muons
$\sigma_{pT}/p_T \approx 5\%$ for 1 TeV muons

Solenoid Magnet
Magnetic field ≈ 3.8 Tesla

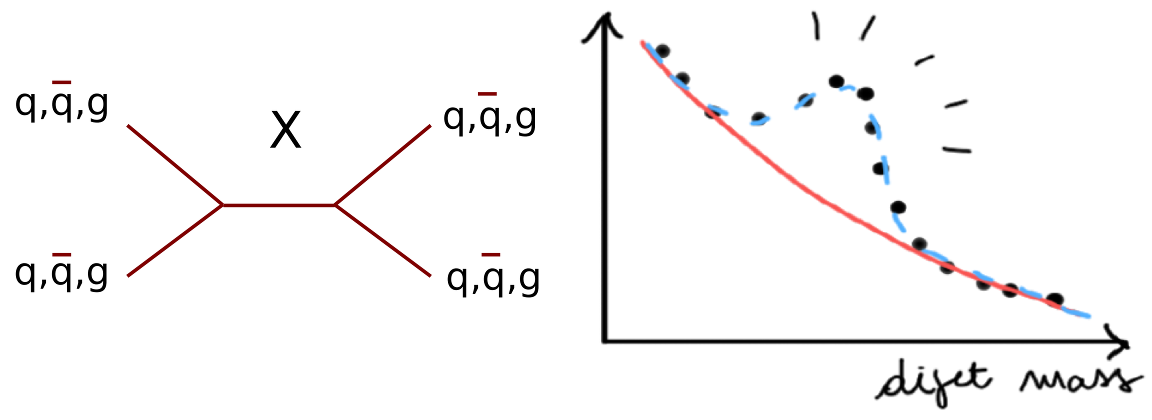
Jet Reconstruction

- Particle Flow Algorithm combines all information from several sub-detector systems.
- Individual particles are reconstructed with Particle Flow Algorithm and then clustered into jets using the anti-k_T algorithm.



Signal Dijet Events

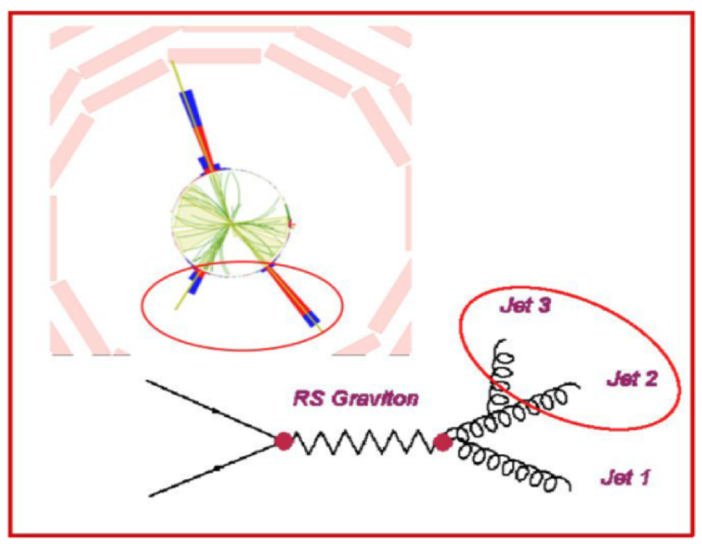
New Physics Models predict the existence of unstable particles that decay (via the s-channel) in partons yielding in a narrow resonance (*Γ/M < experimental resolution*) in the dijet mass spectrum (signal events).



Reconstruction and Selection

Wide Jet Reconstruction

For recovering the Final State Radiation we use "Wide Jets" which give better sensitivity than AK4.

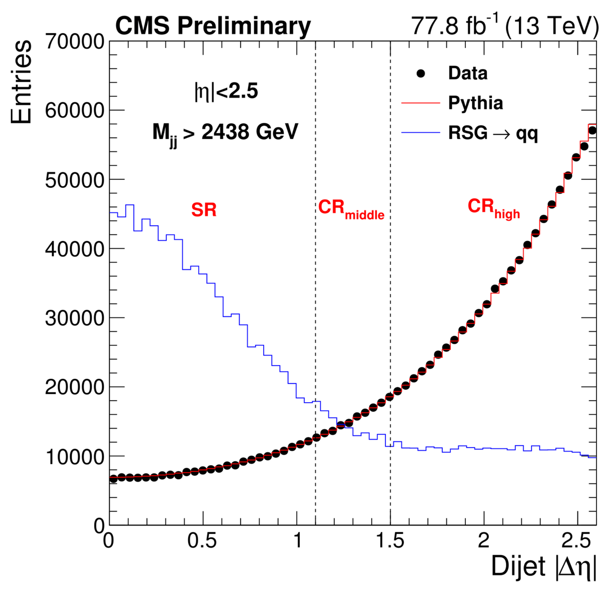


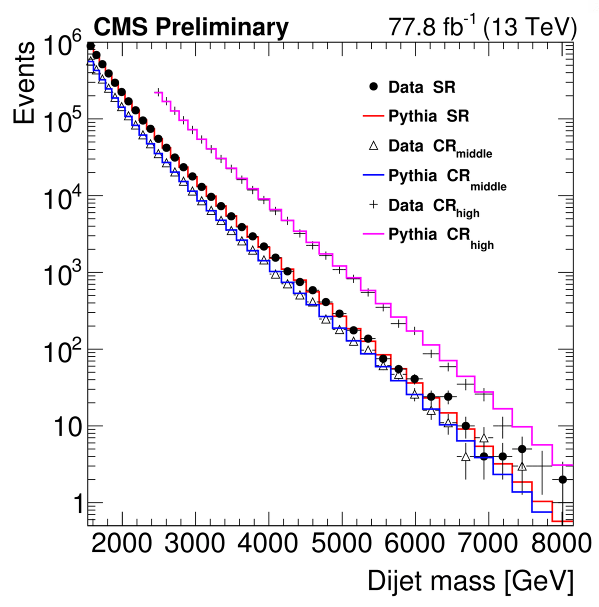
Dijet Event Selection:

- |Δη wide| < 1.1 suppresses QCD (mainly t-channel) and enhances signal (s-channel)
- Dijet Mass > Trigger threshold for full efficiency

Analysis Methodology

Analysis strategy: The main QCD background is estimated using two orthogonal and complementary approaches: In the low end of the spectrum a fit with an empirical function is performed, while in the high end a new data-driven methodology is utilized, the "Ratio Method".



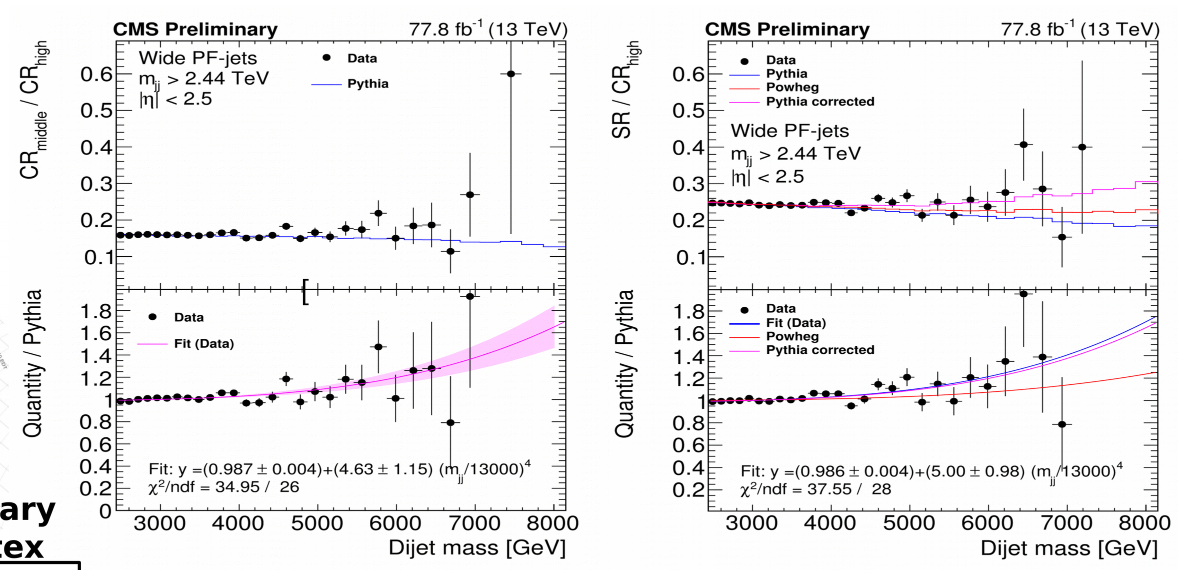


- |Δη| distribution is split into the signal (SR) and two control regions (CR_{middle}, CR_{high}) yielding very similar dijet mass spectra shape-wise.

Ratio Method Prediction

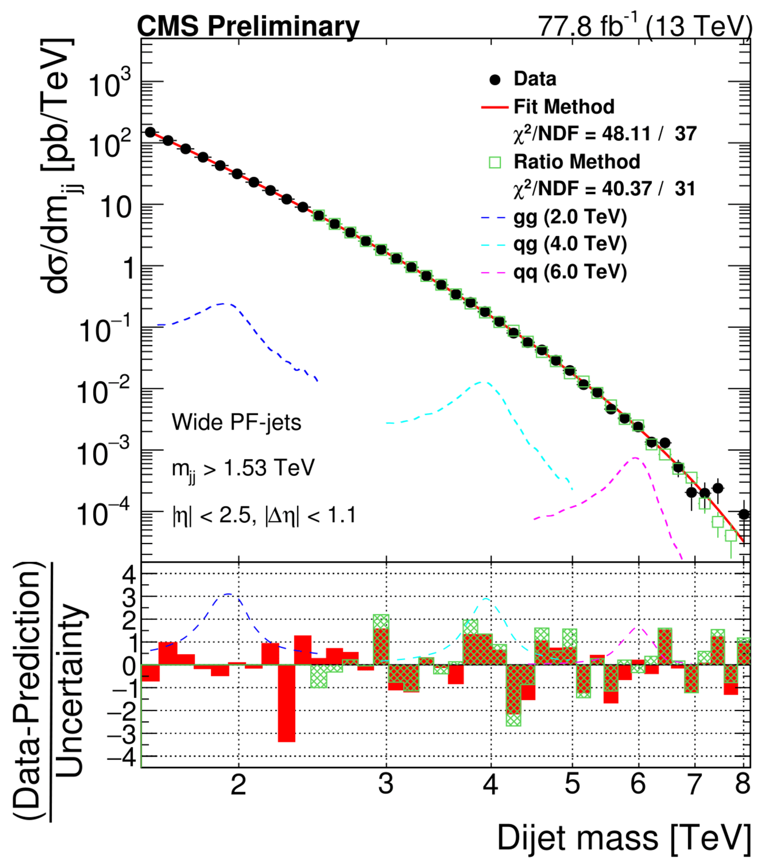
$$N(m_{jj})^{Pred}_{SR} = R_{ext} \times N(m_{jj})^{Data}_{CR_{high}}$$

$$R_{ext} = Corr(m_{jj}) \times N(m_{jj})^{MC}_{SR} / N(m_{jj})^{MC}_{CR_{high}}$$



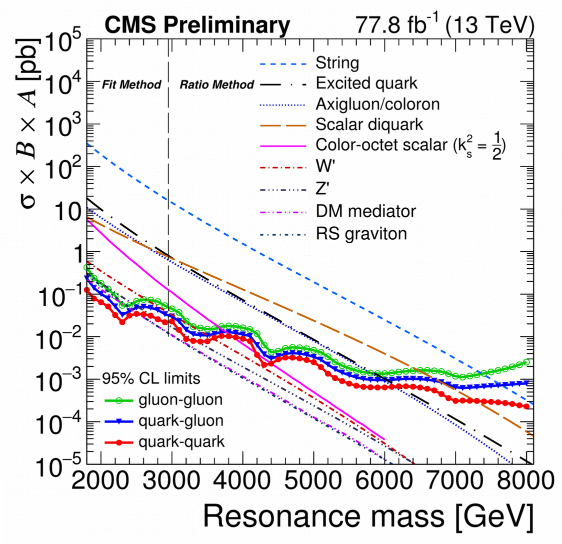
- **Ratio Method Advantages**:
  - In the presence of a signal, two orthogonal methods exist for the background prediction.
  - In case of a signal, the Ratio Method leads to less biased significance values due to smaller systematics.
  - The ratio method yielding a more rigid background parametrization has increased sensitivity as the resonance width increases.

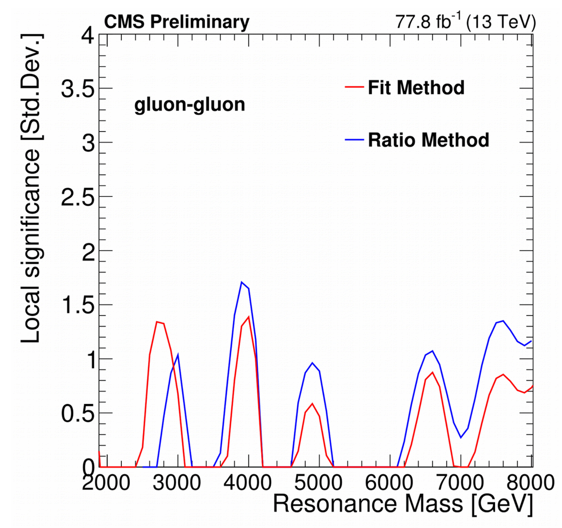
Results with 78 fb^{-1}



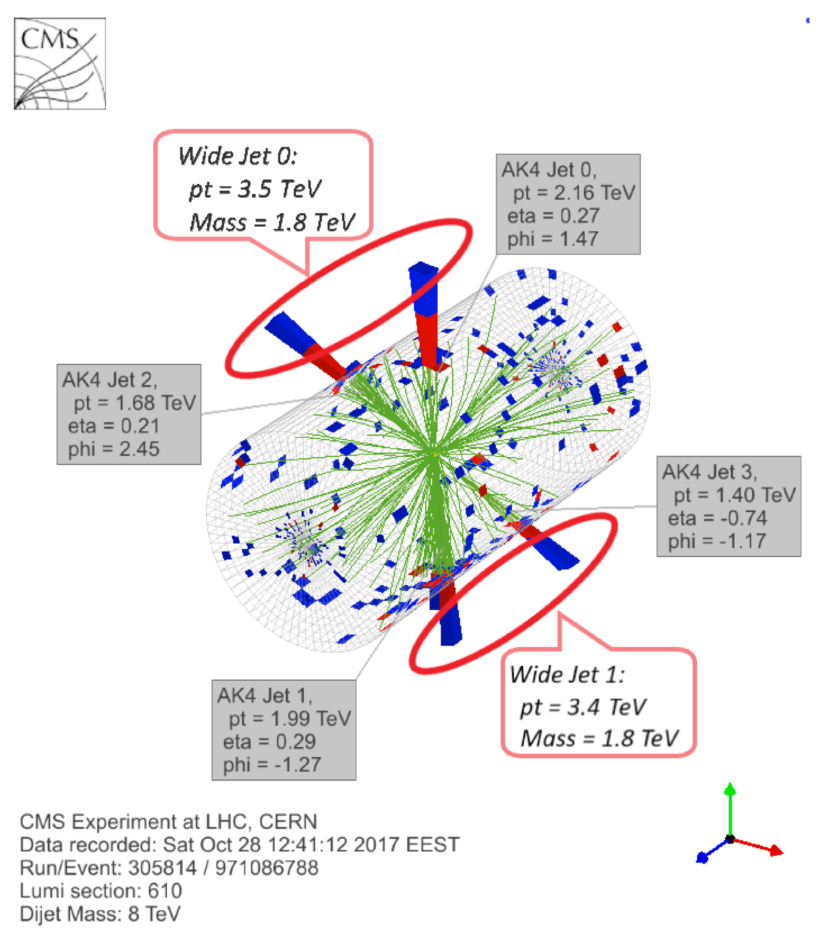
The dijet mass spectrum is well modeled by both background prediction methods which also agree with one another.

Cross section limits & significances





This analysis extends previously reported limits in the dijet channel, and also excludes the dark matter mediator within the mass interval between 3.1 and 3.3 TeV.



The highest dijet mass event at 8 TeV is unusual, being composed of four PF jets combined in two wide jets with the same dijet mass.

Outlook

- Include a search for wider resonances for the Run II legacy paper.
- Planning on producing b-tagged results.
- Planning new analyses to extend reach to lower resonance masses.

References:

- CMS-EXO-17-026
- Particle-flow reconstruction and global event description with the CMS detector, arXiv:1706.04965
- The anti-k_T jet clustering algorithm, arXiv:0802.1189